

Project Schedule and Public Involvement Plan

M1

Needs and Opportunities

M2

Identification of Alternatives

M3

Evaluation of Alternatives

M4

Regional Commuter Rail/High-Capacity Transit Plan

M5

Final Report

M6



→ **MILESTONE 6**
FINAL REPORT
DRAFT EXECUTIVE SUMMARY

March 2003

HIGH-CAPACITY TRANSIT PLAN

Maricopa Association of Governments



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1.0 Introduction and Project Management

The High Capacity Transit Plan presents a network of new transit services designed to meet growing travel demand in the Maricopa Association of Governments' (MAG) region. The study was designed to estimate projected travel demand in the MAG region with a forecast horizon year of 2040. The Draft 2 MAG Population and Employment forecasts were used as the base for estimating ridership and travel demand in the region. These forecasts incorporate updated general plan land use information from each city in the MAG region. Recommendations contained in this report will be incorporated into the development of the Regional Transportation Plan (RTP), which will provide a policy framework to guide regional transportation investments over the next twenty years.

High capacity transit encompasses several different technologies, each designed with different operating characteristics and objectives for moving people. The focus of this study was to identify proven transit technologies that were capable of meeting the levels of travel demand projected in the MAG region while also serving several types of trips, both long-range and short distance.

The High Capacity Transit Plan study process was performed over the course of a 12 month timeframe. The Scope of Work for the project was divided into six milestones described below:

- Study Initiation - Scope of Work, public involvement plan, review of past studies, and comparison of high-capacity transit technologies.
- Needs and Opportunities - Identification of transit performance thresholds, develop modeling methods, and inventory rail infrastructure.
- Identification of Alternatives - Commuter rail feasibility, define a network of services, and identify alternative high-capacity concepts.
- Evaluation of Alternatives - Identify costs, project ridership levels, and evaluate a range of transit alternatives and potential corridors.
- Regional Commuter Rail/High-Capacity Transit Plan - Recommend a transit network and prepare an implementation plan.

The sixth and final project milestone is the release and adoption of the High Capacity Transit Plan Final Report.

1.1 Public and Agency Involvement Plan

The Public and Agency Involvement Plan (PIP) provided an overview of public involvement objectives for the MAG High Capacity Transit Plan. An effective and well-defined PIP allowed MAG to provide outreach to citizens of the MAG region, political leaders, social service organizations, special interest groups and other agencies. These outreach efforts were designed to result in a greater understanding of the project and its

objectives by members of these groups. The overall goal of the outreach effort is to create a document or plan which is endorsed by a coalition of groups representative of the residents of the MAG region.

1.2 Project Stakeholder Interviews

Two of the key elements of the Public Involvement Plan are to incorporate a variety of community interests and provide the opportunity for community decision-makers to share points of view on regional growth, transportation policies, and the future of commuter rail in the Phoenix area. A series of stakeholder interviews were conducted to address these elements, focusing discussion on a series of topics related to the High Capacity Transit Plan.

With nearly 30 stakeholders representing 16 organizations, agencies and jurisdictions in Maricopa County, a limited number of major themes were identified, but the perspectives from the stakeholders are very diverse. Major topics of discussion included:

- General agreement on the initially proposed corridors, with recommendations for additional study corridors.
- A favorable opinion of the Central Phoenix/East Valley LRT. Desire for expansion of the benefits of this system to other areas of the MAG region.
- Interest in administration and management of transit services.
- Interest in ways to integrate land use and transportation planning.
- Concern about funding and financing for transit improvements, as well as phasing timeframes for proposed improvements.

1.3 Review of Current and Previous Transportation Studies

The High Capacity Transit Plan was conducted concurrently with several other transportation studies and projects. Results from these other study efforts were reviewed during the development of this study to identify ways that the High Capacity Transit Plan could be coordinated with the recommendations of the studies and proposed projects. Regular working group meetings were held with the representatives developing the other studies to share results and conclusions to ensure consistency in the recommendations of several studies that will be incorporated in the Regional Transportation Plan.

Selected current and recent regional transportation studies reviewed during the development of recommendations for this report included previous commuter rail demonstration studies, the Central Phoenix/East Valley MIS, the Scottsdale-Tempe North-South MIS, the Chandler Transit MIS, the three MAG Area Transportation Studies (Northwest, Southwest, Southeast), and the MAG Fixed Guideway Transit Study.

2.0 High Capacity Transit Characteristics and Thresholds



Commuter Rail
in Dallas, TX



Heavy Rail in
Chicago, IL



Light Rail in
San Diego, CA



Automated Guideway
Transit in Miami, FL



Bus Rapid Transit
in Las Vegas, NV

A comprehensive review of high capacity transit technologies was needed to identify technologies capable of meeting the projected travel patterns and demand present in the study area.

2.1 General Characteristics of High Capacity Transit

Five proven transit technologies were evaluated for implementation in the transit corridors identified in the High Capacity Transit Plan. In addition to these proven technologies, several other existing and new technologies were studied, including Diesel Multiple Unit (DMU) vehicles. The five primary transit technologies evaluated were commuter rail, heavy rail, light rail transit (LRT), automated guideway transit, and bus rapid transit (BRT).

2.2 Peer Group Transit System Review

Three transit technologies were selected for inclusion in a peer-group review of transit systems. The three technologies were commuter rail, LRT, and BRT. These technologies were selected because of their prevalence in North America and their potential appropriateness for implementation in the MAG region.

Table 2-1 lists the six transit systems for each of the three technologies included in the peer group review. Operating data for the Year 2000 and socio-economic data for selected systems was collected from each agency and the United States Census.

Table 2-1

General Peer Group Review Transit Systems

Commuter Rail	Light Rail	Bus Rapid Transit
Los Angeles - Metrolink	Los Angeles - Green Line	Los Angeles - Metro Rapid
San Diego - Coaster	San Diego - Blue Line (Mission Valley)	Miami - South Miami-Dade Busway
San Jose - Altamont Commuter Express	Dallas - Red and Blue Lines	Pittsburgh - South, East, and West Busways
Dallas - Trinity Railway Express	Denver - Central and Southwest Lines	Vancouver - Richmond to Vancouver Rapid Bus
Toronto - Lakeshore East Line	San Jose - VTA Light Rail	Ottawa - Transitway
Chicago - South Shore Line	St. Louis - Metrolink	Washington DC - Dulles Corridor BRT

Analysis of Peer Group Data

The three peer group systems selected for inclusion in the detailed data review possess a wide variety of population and employment densities. Specific patterns emerging from the data include:

- Commuter rail systems selected in this peer group review are capable of maintaining successful operations in corridors with lower population and employment densities than those in LRT and BRT corridors.
- Each light rail or BRT system serves a minimum of one employment center (greater than 50 employees per acre) while two of the selected commuter rail systems serve corridors with more dispersed employment centers and no census tracts with greater than 50 employees per acre.
- All but one transit system operates within a metropolitan region with over 50 percent of the region's freeway lanes miles extremely or severely congested.
- Average trip lengths for commuter rail systems are a minimum of 25 miles. These averages are between four and nine times as long as the average trip lengths for light rail and BRT.

The peer group review also examined population densities for several representative corridors in the MAG region and compared them to the data collected on the peer review transit systems. The results from the MAG region were generally comparable with the existing transit systems throughout North America.



The photos above present three of the peer group transit systems reviewed in this study: Commuter Rail in Los Angeles, CA, Light Rail in San Jose, CA, and Bus Rapid Transit in Miami, FL.

3.0 MAG High Capacity Transit Corridor Identification

During the development of the High Capacity Transit Plan, 29 corridors were identified for possible inclusion in the Recommended Network. For the purposes of analysis, a single alignment was selected for each of these corridors. However, these specific alignments are designed to represent all parallel alignments in the corridor including streets, freeways, rail lines, and non-traditional corridors such as canals or power-line easements.

These corridors were developed from three sources:

1. Current and past major transportation studies in the MAG region.
2. Suggestions of agency representatives in the stakeholder interviews.
3. Existing and future demographics and travel patterns in the region.



Three major corridors in the MAG region are illustrated above: I-10 West (top), Union Pacific Southeast (center), and Camelback Road (bottom).

Two networks of proposed transit enhancements were developed using the corridors identified above. Each of these networks was developed using a set of base transit alternatives, which included both a radial and grid orientation to providing service. Potential commuter rail, LRT, and BRT services are included within each network, and are illustrated in Exhibits 4-1 and 4-2. These networks were used as the basis for evaluating the corridors and identifying locations where individual corridors could connect and create an integrated regional network. Summaries of the two transit networks are provided below:

Network 1 – This network is a combination of commuter rail, Express BRT and LRT/Dedicated BRT systems, serving both long and short distance trips with a series of radial alignments.

Network 2 – This network is designed to serve long and short distance trips with long distance radial corridors linked to the grid system of LRT and BRT service.

The corridors developed using these sources were numerous, and in many cases, the corridors overlapped or served the same markets. As a solution to this issue, multiple parallel corridors were combined or modified so that the various rail, arterial street, freeway or flood control channel rights of way could easily map to a specific major corridor. The results of these combinations are present in the ridership and cost estimates in Section 4.

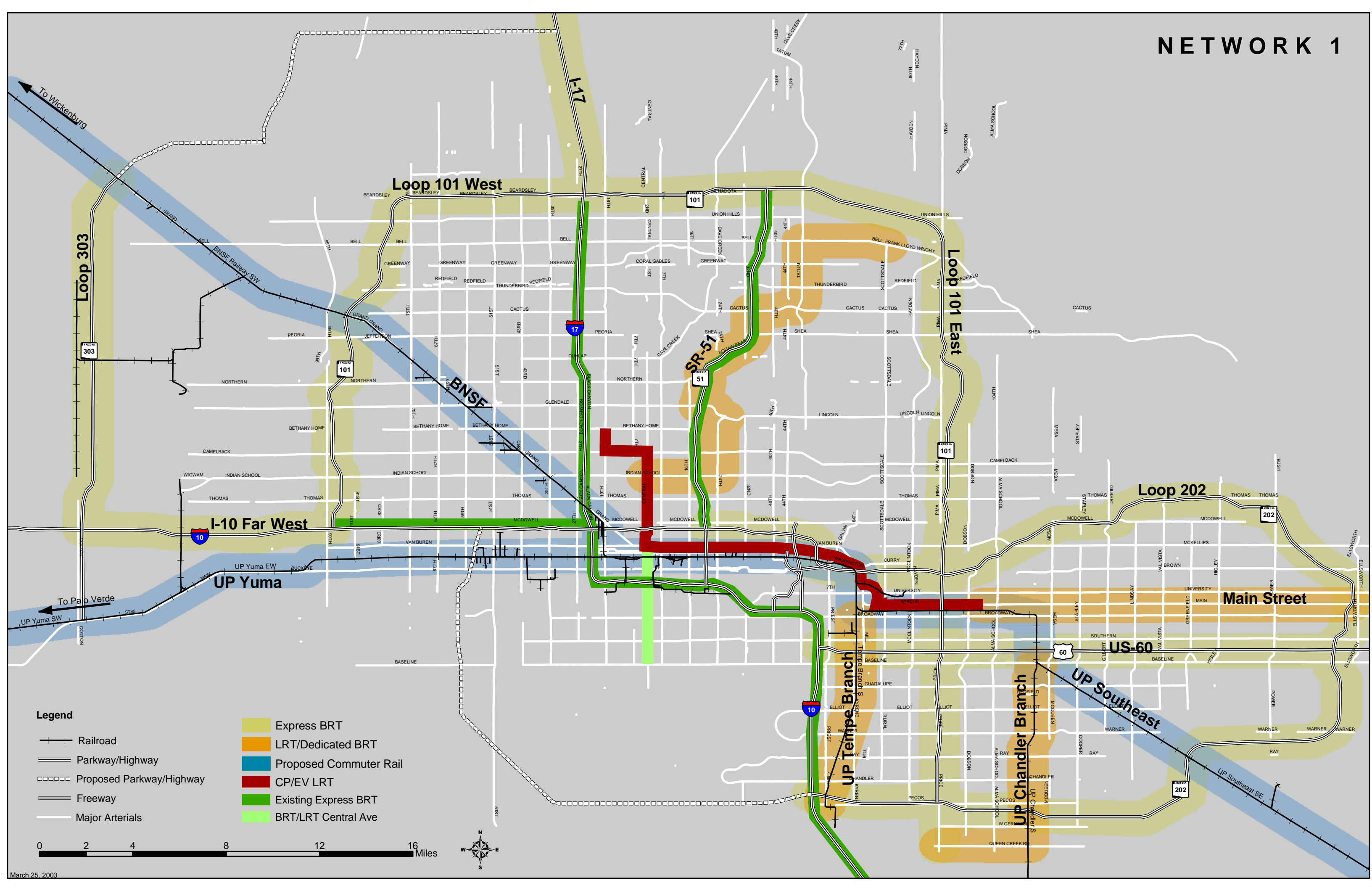
During the initial screening process, several corridors were eliminated from further consideration. In particular, all proposed Express BRT corridors were screened out of the review process. These corridors possess operating characteristics which are very different those of a commuter rail, LRT, or Dedicated BRT systems. The evaluation of the Express BRT corridors was shifted to the Valley Metro/RPTA Regional Transit System Study since it was determined that the Express BRT corridors “fit” better with the scope of this study.

3.1 Commuter Rail Network and Operating Characteristics

Three levels of service for the operation of a commuter rail system were initially identified for the MAG region.

- Phase 1: Start-Up/Introductory Services: limited peak hour, peak direction service composed of three trains inbound in the a.m. peak and outbound in the p.m. peak on each of the corridors.
- Phase 2: Intermediate Services: Headways of 20 minutes peak hour will be examined together with limited counter-flow service. Midday service would consist of hourly trains in each direction.
- Phase 3: Full Commuter Train Operation: 15 minute headways during the peak hours and at 30 minute headways during the off-peak, with peak period 30 minute interval counter-flow services.

NETWORK 1



Legend

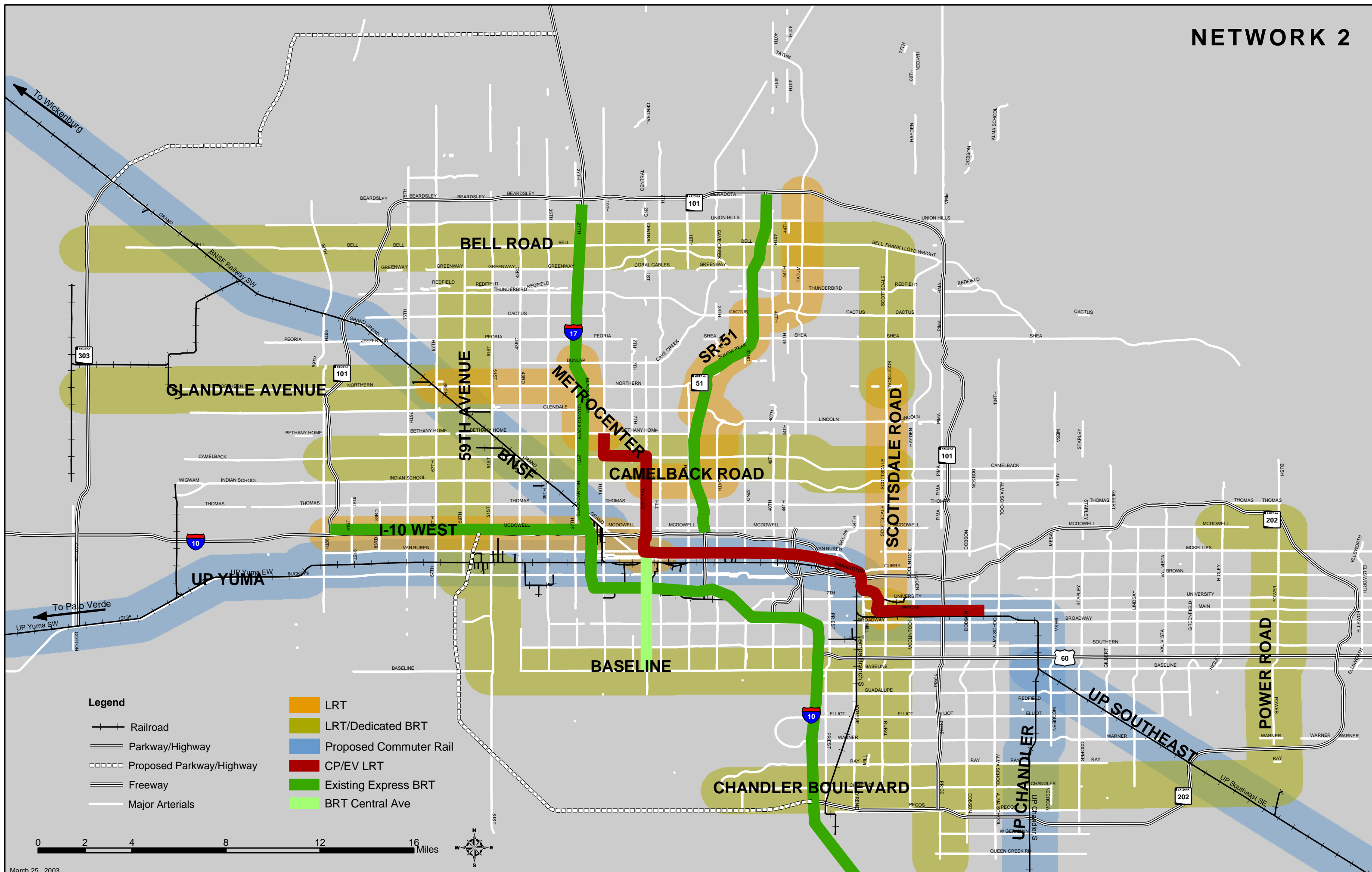
- Railroad
- Parkway/Highway
- Proposed Parkway/Highway
- Freeway
- Major Arterials

- Express BRT
- LRT/Dedicated BRT
- Proposed Commuter Rail
- CP/EV LRT
- Existing Express BRT
- BRT/LRT Central Ave

0 2 4 8 12 16 Miles



NETWORK 2



These three levels of service were used to develop the ridership and cost estimates in Section 4. Based upon the results of the capital cost estimates and discussions with representatives from BSNF and UP, it was determined that only the Phase 1 and Phase 3 levels of service would be carried forward for further evaluation. Phase 1 service represents the minimum amount of service that needs to be provided to operate a potentially viable commuter rail service, with three trains operating during the peak commute. Phase 3 service would be the ultimate operation of commuter rail service which would provide residents of the MAG region with a true “turn up and go” service providing frequent and reliable service throughout the day during both peak and off-peak commute times.

Infrastructure Requirements

Discussions were held with Burlington Northern Santa Fe (BNSF) and the Union Pacific (UP) Railroads to identify infrastructure enhancements required for implementing commuter rail service in freight rail corridors in the MAG region. In summary, assuming no changes to the operating practices of BNSF and UP, a second main track will be required on the BNSF line between downtown Phoenix and Surprise. The Union Pacific corridor will require a second main track between downtown Phoenix and the McQueen Junction in Gilbert, just south of US-60. Additional infrastructure improvements required in these corridors include stations, signals, and sidings to allow for trains to pass each other. A full discussion of the infrastructure requirements by segment is included in the Milestone 3 Report.

Common Issues in Commuter Rail Operations

Over the past two decades, there has been a wave of “start-up” commuter rail operations, particularly in the western United States. Based on that experience, the following are some typical issues likely to arise in ongoing discussions of commuter rail in the MAG region including potential resolution mechanisms and lessons learned from other systems.

- Ownership – The commuter rail agency can either purchase freight right-of-way or lease access.
- Capacity Conflicts – Coordination between passenger rail and freight rail traffic is essential to ensure efficient operations for both.
- Grade Crossings – Street/rail crossings could cause impacts to automobile traffic in the corridor.
- Noise – Additional rail traffic can impact sensitive uses.
- Station Impacts – Additional automobile traffic is created near stations as commuters access park-and-ride facilities.

- Capital Needs – Rail infrastructure and vehicles must be purchased and maintained.
- Governance – How is the system administered when the corridor passes through several jurisdictions.

Commuter Rail Equipment

All new start commuter rail systems in North America have been equipped with an almost uniform configuration of a diesel locomotive-hauled train of double deck cars. Commuter rail services in this configuration are operated in push-pull mode, with a locomotive at one end and a cab car at the other end; these trains can reverse without any changes to the train makeup. This study examined the operation of this technology in the MAG region along with a new technology in North America called diesel multiple unit (DMU) trains. A comparison of these technologies is included in Section 4.



Conventional commuter rail locomotive technology is illustrated in the top photo. A new DMU vehicle from Colorado Rail Car is shown in the bottom photo.

3.2 LRT/Dedicated BRT Network and Operating Characteristics

In addition to commuter rail services, other types of high capacity transit services are also being considered for implementation in the MAG region. These alternative high capacity transit services include LRT and BRT. Corridors that present possible alignments for LRT and BRT services include arterial streets, freeways, and non-traditional transportation corridors such as utility easements and flood control channels. Both technologies are capable of being implemented in either elevated or at-grade configurations. Additional options for minimizing traffic impacts and improving system operating speeds are also available in form of reserved rights-of-way or exclusive travel lanes.

Technology Comparison

An important determination made during the development of the BRT and LRT corridors is the identification of which technology is better suited for implementation in a particular corridor. Both LRT and BRT are extremely flexible transit services capable of operating in a variety of corridors and configurations. In terms of operational characteristics, BRT and LRT both have advantages and disadvantages that would need to be analyzed on a corridor-by-corridor basis in order to determine the right technology “fit” for new high capacity transit system. A detailed Major Investment Study (MIS) is required to fully and properly analyze each technology.



The Green Line light rail in Los Angeles, CA operates in a freeway median.



Bus Rapid Transit in Ottawa, Canada is operated in an exclusive transitway.

	Light Rail Transit	Bus Rapid Transit
Advantages	<ul style="list-style-type: none"> • Positive impact upon land use development within the corridor • Increased vehicle capacity 	<ul style="list-style-type: none"> • Flexibility in operating and phasing • Ability to operate as short-term service
Disadvantages	<ul style="list-style-type: none"> • Limited ability for phased implementation • Higher capital investment cost than BRT 	<ul style="list-style-type: none"> • Image of bus vehicles as slow • Reduced vehicle capacity

Each of these technologies is highly scalable and the implementation of one technology tends to encourage the continuation of that technology in future expansions and extensions of the initial corridor. However, selecting one technology over the other does not preclude the implementation of both LRT and BRT in the same metropolitan region. These two technologies coexist in many regions including Los Angeles, Pittsburgh, and Cleveland. In the end, technology selection is not only a local decision, it is a regional one that should include input from all stakeholders region-wide to order to bring the greatest benefit to the largest number of people.

4.0 Ridership and Cost Estimates

Cost and ridership are provided in this section for the potential high capacity transit corridors in the MAG region. As noted previously, each alignment identified in the tables below represents a single centerline street or freeway selected for ridership, cost and socio-economic data estimates. The actual corridors are approximately five miles in width and a final alignment could include other streets parallel to the alignments identified. Ridership and cost estimates were developed using population projections, operating and implementation characteristics of peer systems, and input from the Agency Working Group, a committee of representatives from MAG, local cities, Valley Metro, and the Arizona Department of Transportation who convened throughout the study process to review and refine the inputs and results of this study. Exhibit 4-1 illustrates the high capacity transit network recommended for evaluation and the development of ridership and cost estimates.

4.1 Commuter Rail Ridership

Commuter rail ridership was forecast using a direct demand model (DDM). The more traditional four stage modeling approach was considered less suitable at the initial stage due to the absence of commuter rail as a mode in the MAG model, and the much slower application of this model when compared to the quick sketch planning forecasts that the DDM can produce. Instead, the four-stage MAG model was used to evaluate the overall Recommended High Capacity Transit Network. The results of this model evaluation are presented later in this report.

The DDM estimates weekday boarding passengers per station based on the catchment population and level of service factors such as train frequency and journey time savings. Station catchment areas were developed for each proposed station to represent the major source of all trip origins within a ten mile radius, taking into account for land use development patterns present in the MAG region and likely travel distances for commuters based upon reviews of riders from other West Coast commuter rail services.

Table 4-1 displays the average weekday ridership forecast for the corridors.

Table 4-1

Commuter Rail Total Ridership Forecasts

Corridor	Total Boardings	
	Initial 2020 - (Phase 1)	Ultimate 2040 - (Phase 3)
BNSF	4,862	16,145
UP Mainline/Chandler	1,372	4,561
UP Southeast	1,970	6,471
UP Yuma	2,710	12,034

Note: These boarding figures have been obtained from a sketch planning model.

4.2 Commuter Rail Capital and Operating Costs

Capital and operating costs have been developed for the four alternative commuter rail corridors consistent with the phased levels of service described above using conventional locomotive-hauled equipment. Capital costs were developed using standard unit cost rates obtained from several rail infrastructure cost estimates prepared for West Coast rail properties during the previous five years. Commuter rail operating costs have been estimated using the comparison of Year 2001 bus and commuter rail operating and maintenance costs from three commuter rail service providers, the Dallas Trinity Railway Express, San Diego Coaster, and San Jose Altamont Commuter Express. Table 4-2 summarizes the capital costs for each commuter rail corridor by phase.

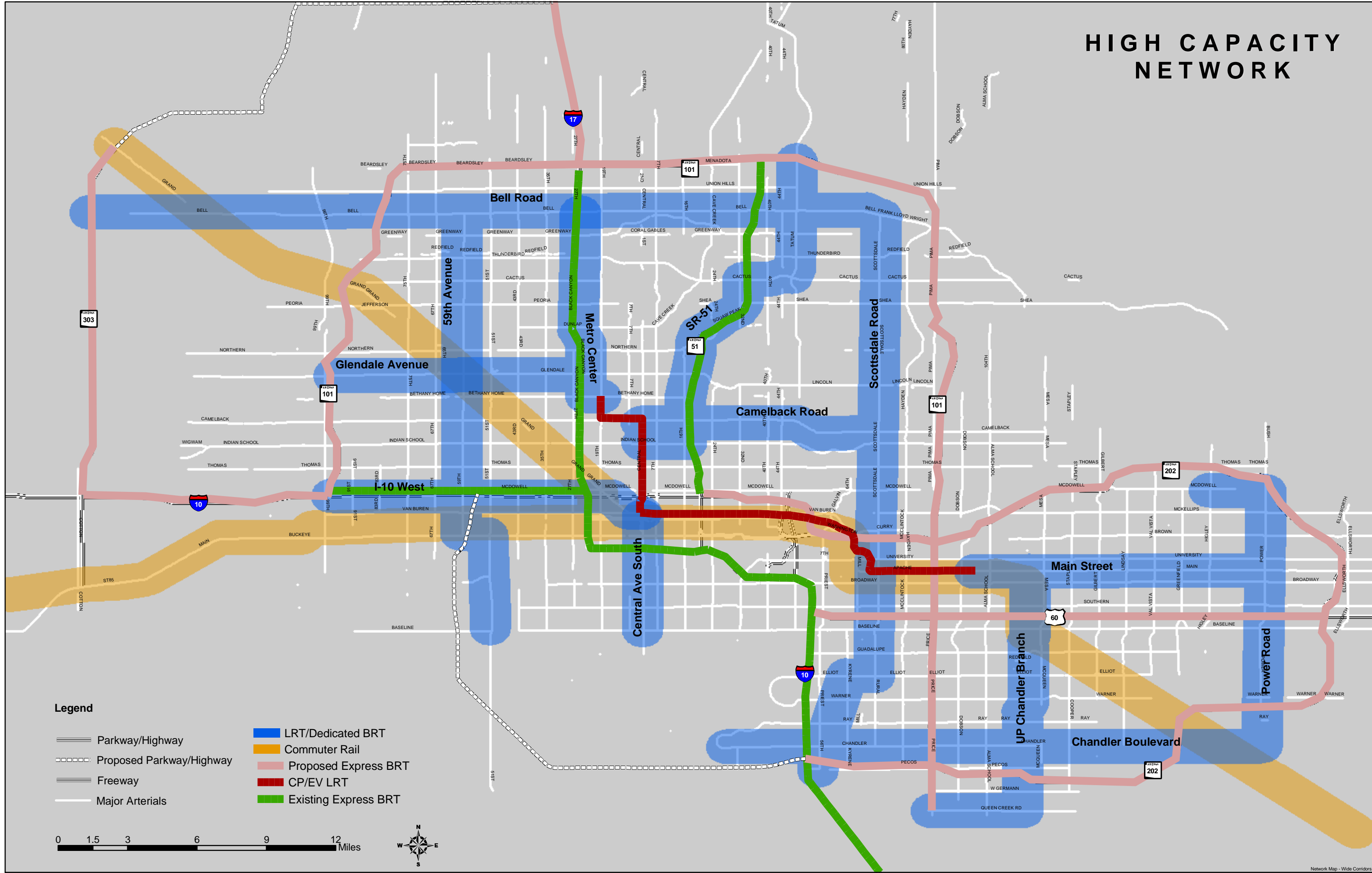
Table 4-2

Commuter Rail Capital & Operating Costs

Commuter Rail Corridor	Capital Costs	Annual Operating Cost
BNSF Phase 1	\$292.30	\$4.90
BNSF Phase 3	\$445.63	\$22.55
BNSF Capital Cost Total	\$737.93	n/a
UP Mainline/Chandler Phase 1	\$269.93	\$1.85
UP Mainline/Chandler Phase 3	\$260.29	\$14.25
UP Mainline/Chandler Capital Cost Total	\$530.22	n/a
UP Southeast Phase 1	\$270.34	\$3.05
UP Southeast Phase 3	\$297.15	\$17.50
UP Southeast Capital Cost Total	\$567.50	n/a
UP Yuma Phase 1	\$143.25	\$3.60
UP Yuma Phase 3	\$308.55	\$22.40
UP Yuma Capital Cost Total	\$451.80	n/a

Note: All costs are in millions of dollars and Year 2001 dollars.

HIGH CAPACITY NETWORK



Alternative Commuter Rail Technologies

The Diesel Multiple Unit (DMU) rail vehicle has been successfully used in Europe for many years, but had not appeared in North America due to the inability of existing designs to meet Federal Railroad Administration (FRA) safety regulations. However, several manufacturers are developing FRA-compliant DMU vehicles. Given the long-term nature of this study, it is reasonable to explore a scenario where DMUs are fully certified by the FRA for use in mixed freight and passenger corridors.

DMUs possess several operational advantages over conventional locomotive trains. The DMU vehicles are usually less expensive than a comparable locomotive-hauled unit on a per passenger basis, are more fuel-efficient, and are capable of quicker acceleration and deceleration rates thanks to lower overall weight. Disadvantages include the need for additional vehicles if single-level vehicles are selected, possible increases in maintenance costs due to the relative uniqueness of the technology in North America, and possible limited life cycle.

Capital and operating costs have been developed for the implementation of commuter rail service using DMU trains and are presented in the Milestone 5 Report. The cost effectiveness of operating commuter rail service in the MAG region with the three types of rail vehicles is presented in Table 5-1 below. A full discussion of the calculation of cost-effectiveness in this report is presented in Section 5.

Table 4-4 DMU Cost Effectiveness Comparison

Corridor	Colorado Rail Car DMU Cost Effectiveness	Bombardier Talent DMU Cost Effectiveness	Conventional Locomotive Cost Effectiveness
BNSF Phase 3	\$16.40	\$16.31	\$16.84
UP Mainline/Chandler Phase 3	\$37.48	\$32.82	\$41.41
UP Southeast Phase 3	\$30.07	\$29.87	\$33.83
UP Yuma Phase 3	\$15.32	\$15.43	\$16.22

Note: All costs are in Year 2001 dollars.

As shown in the two tables above, DMU technology does offer a potentially cost-effective alternative to conventional locomotive-hauled commuter trains. The relative uniqueness of the DMU technology in North America may create some procurement and maintenance issues. However, as the technology becomes more prevalent, these additional risks and costs will be minimized. Given the long-term horizon of this study it remains prudent to retain DMU technology as a possible option for providing commuter rail service in the MAG region. The selection of a specific technology for commuter rail in a selected freight corridor in the MAG region would require a detailed Major Investment Study (MIS).



The photos above illustrate the three commuter rail vehicles: conventional locomotive (top), Colorado Rail Car DMU (middle), and Bombardier Talent DMU (bottom).

4.3 Light Rail/Bus Rapid Transit Ridership

Similarly to the commuter rail forecasts, a direct demand modeling approach was used, in this case the MAG Sketch Plan Model, which is particularly suited to the level of detail required at this stage and was selected as a tool for the rapid development of corridor forecasts. Forecasts shown in Table 4-5 are for average daily ridership.

Table 4-5

LRT/Dedicated BRT Ridership Projections

Corridor	Length	Average Daily Boardings	Boardings per Mile
59th Avenue	19	12,829	675
Bell Road	29	19,750	691
Camelback	9	8,126	945
Central Avenue South	5	5,749	1,150
Chandler Boulevard	17	12,226	741
Glendale Avenue	10	7,226	737
I-10 West	11	13,765	1,251
Main Street	10	9,697	1,010
Metrocenter/I-17	9	8,848	1,005
Power Road	13	8,653	666
Scottsdale Road/Tempe Branch	26	20,672	811
SR-51	17	12,334	713
UP Chandler Branch	13	12,534	995

Notes: The boarding figures contained within this table have been obtained from a sketch planning model

Many of the corridors perform well in comparison with existing LRT systems in San Diego, Portland and Sacramento, including parts of the Scottsdale Road and Glendale Avenue corridors, Main Street, and the Metrocenter/I-17 corridor.

4.4 Light Rail/Bus Rapid Transit Capital and Operating Costs

The LRT capital costs assume an at-grade alignment except when crossing rivers, flood control channels and freeways. In these locations, the alignment is elevated in order to minimize impacts to existing arterial streets and bridge facilities. These cost estimates are planning level estimates that have been produced without the benefit of detailed plans. More precise costs would be produced in the latter stages of project design and development.

Four corridors noted below do not have Dedicated BRT costs. Central Avenue South, Metrocenter/I-17, Glendale Avenue, and I-10 West were analyzed solely as LRT corridors, and as is the case with the other

corridors, these alignments were selected to represent corridors approximately two to five miles in width. LRT has been identified as the preferred technology on Main Street in Mesa between the terminus of the CP/EV LRT and downtown Mesa. The preferred technology beyond this point has not been determined. As such, two costs estimates have been prepared for this corridor.

Light rail operating costs have estimated using a parametric model developed for the Tri-Met LRT system in Portland, Oregon. Model inputs have been adjusted by comparing bus operating costs for Valley Metro/RPTA with Tri-Met bus service. The use of these model inputs eliminates the need for comparisons between multiple light rail systems as was the case in developing commuter rail operating costs. Instead, the parametric model is designed to produce consistent results even when applied to different light rail systems in different metropolitan areas because the model is based upon the bus service costs within the metropolitan region. Operating costs for the Valley Metro/RPTA bus service in 2001 were used as a base for estimating the operating cost of Dedicated BRT service.

Table 4-6 presents the capital and operating costs for both the LRT and Dedicated BRT corridors.

Table 4-6 LRT/Dedicated BRT Estimated Capital and Operating Costs

LRT Corridor	LRT Capital Costs (\$ millions)	LRT Annual O&M Cost (\$ millions)	BRT Capital Costs (\$ millions)	BRT Annual O&M Cost (\$ millions)
59 th Avenue	\$727.81	\$11.29	\$359.08	\$10.29
Bell Road	\$1,102.24	\$22.55	\$539.11	\$15.64
Camelback Road	\$349.36	\$7.63	\$165.65	\$4.91
Central Avenue South	\$228.03	\$4.83	n/a	n/a
Chandler Boulevard	\$683.75	\$9.74	\$306.02	\$6.59
Glendale Avenue	\$429.22	\$8.96	n/a	n/a
I-10 West	\$399.34	\$10.29	n/a	n/a
Main Street	\$373.63	\$8.96	\$184.71	\$5.35
Metrocenter/I-17	\$337.65	\$7.61	n/a	n/a
Power Road	\$465.10	\$8.26	\$236.83	\$3.71
Scottsdale Road	\$1,010.84	\$20.95	\$465.96	\$14.00
SR-51	\$823.28	\$14.34	\$254.67	\$9.47
Union Pacific Chandler Branch	\$460.86	\$10.44	\$225.92	\$7.00

Note: All costs are in Year 2001 dollars.

5.0 Evaluation of Alternatives

The High Capacity Transit corridors identified in this study were evaluated using a measure of project cost effectiveness developed specifically for this study. Table 5-1 summarizes the results of the ridership and cost estimates presented in Section 4 above. Included in the final column of Table 5-1 is the cost effectiveness category. Cost effectiveness is a measure used by the Federal Transit Administration (FTA) as part of the Section 5309 “New Starts” program, which allocates federal capital funding for major transit investment projects. For this program the cost effectiveness of the project is measured using the following calculation:

$$\frac{(\text{Project annualized capital cost} + \text{Project annual operating cost}) - (\text{Baseline annualized capital cost} + \text{Baseline annual operating cost})}{(\text{Total Project Annual Riders} - \text{Total Baseline Annual Riders})} = \text{Cost Effectiveness}$$

This calculation relies upon a baseline of future transit assumptions and difference between the proposed project and this baseline set of improvements. The corridors and high capacity transit systems here have not been matched to a specific baseline level of transit investment, making it impossible to exactly match the calculation above. Instead, a modified calculation of cost effectiveness has been selected for this portion of the evaluation. This calculation is illustrated below:

$$\frac{(\text{Project Annualized Capital Cost} + \text{Project Annual Operating Cost})}{\text{Project Annual Boardings}} = \text{Cost Effectiveness}$$

The cost effectiveness figures presented in this report are designed as a tool to compare the corridors under consideration in the High Capacity Transit Plan. It would not be appropriate or accurate to compare these figures to other projects such as the CP/EV LRT or other transit projects that have received a certain cost effectiveness rating from the Federal Transit Administration (FTA). This measure differs significantly from the measure used in this study. This cost effectiveness rating in this report should be used only to evaluate the corridors in this report against each other.

Benefit Cost

The Benefit Cost analysis, like the cost effectiveness calculation, reflects the relationship between ridership and costs. However, the results of the Benefit Cost are in inverse relation to those of the cost effectiveness calculation. It is important to recognize that the key additional factor at work in the Benefit Cost analysis is the level of roadway congestion forecast for the competing arterial or freeway segment. The Benefit Cost figures identified in this report are designed to act as a check against the cost effectiveness ratings received by each of the corridors, and to assist in recommendations for phasing and prioritization. A full discussion of the Benefit Cost results and methodology is provided in Milestone 5.

Table 5-1

Cost Effectiveness

Corridor	Length (miles)	Weekday Boardings	Annual Boardings	Total Cost	Annual Capital Cost	Annual Operating Cost	Cost Effectiveness	Benefit Cost
I-10 West	11	13,765	5,024,225	\$399,343,813	\$31,947,505	\$10,290,000	\$8.41	2.64
Union Pacific Chandler Branch	13	12,534	4,574,910	\$460,856,044	\$36,868,484	\$10,440,000	\$10.34	0.96
Metrocenter/I-17	9	8,848	3,229,520	\$337,645,412	\$27,011,633	\$7,610,000	\$10.72	1.87
Main	10	9,697	3,539,405	\$373,625,175	\$29,890,014	\$8,960,000	\$10.98	1.11
Central Avenue South	5	5,749	2,098,385	\$228,033,946	\$18,242,716	\$4,830,000	\$11.00	0.50
Camelback	9	8,126	2,965,990	\$349,356,895	\$27,948,552	\$7,630,000	\$12.00	1.31
Scottsdale Rd/Tempe Branch	26	20,672	7,545,280	\$1,010,837,127	\$80,866,970	\$20,950,000	\$13.49	1.61
Power	13	8,653	3,158,345	\$465,103,053	\$37,208,244	\$8,260,000	\$14.40	0.72
Chandler Blvd.	17	12,226	4,462,490	\$683,750,317	\$54,700,025	\$9,740,000	\$14.44	0.97
59th Ave	19	12,829	4,682,585	\$727,809,264	\$58,224,741	\$11,290,000	\$14.85	2.04
Bell	29	19,750	7,208,750	\$1,102,239,771	\$88,179,182	\$22,550,000	\$15.36	1.75
UP Yuma	31	12,034	3,610,200	\$451,799,232	\$36,143,939	\$22,400,000	\$16.22	4.19
Glendale Avenue	10	7,226	2,637,490	\$429,215,236	\$34,337,219	\$8,960,000	\$16.42	1.05
BNSF	26	16,145	4,843,500	\$737,933,062	\$59,034,645	\$22,550,000	\$16.84	1.69
SR-51	17	12,334	4,501,910	\$823,278,568	\$65,862,285	\$14,340,000	\$17.82	2.28
UP Southeast	36	6,198	1,859,400	\$567,495,110	\$45,399,609	\$17,500,000	\$33.83	1.30
UP Mainline/Chandler	28	4,561	1,368,300	\$530,221,490	\$42,417,719	\$14,250,000	\$41.41	n/a

Notes: All ridership figures have been obtained from a sketch planning model. All costs are in Year 2001 dollars. In the case of cost effectiveness the lowest figures represent the best performance, while in Benefit Cost the higher figures are the top performers.

5.1 Analysis of Corridor Evaluation

The evaluation results make commuter rail service in the BNSF and UP Yuma corridors viable when compared to the LRT/Dedicated BRT corridors. The UP Southeast and UP Mainline/Chandler corridors still face challenges given the anticipated cost of implementing service. In light of these challenges, a recommendation has been made to eliminate the UP Mainline/Chandler corridor from consideration for commuter rail service. Nevertheless, it is recognized that this corridor on the UP Chandler Industrial Branch portion between Chandler and Mesa has a large level of travel demand. Given the results of the cost-effectiveness evaluation performed, it is apparent that this demand would be best served by an

LRT/Dedicated BRT corridor paralleling the UP Chandler Branch. Commuter rail demand in the corridor between Mesa and downtown Phoenix would still be served by the UP Southeast corridor. The UP Chandler Branch corridor was specifically reviewed in this analysis and received an excellent cost effectiveness rating (2nd overall). Given this performance by the LRT/Dedicated BRT technology, it is recommended that commuter rail no longer be studied for this corridor.

Despite the lower performance of the UP Southeast corridor compared to the other high capacity transit corridors contained in the recommended network, this corridor remains in consideration for high capacity transit service. This decision has been made considering the regional travel demand in the East Valley and the probable need for fast, long-distance transit service in this portion of the MAG region. Commuter rail is better suited to meeting this demand than are LRT and Dedicated BRT. The UP Southeast corridor faces several cost-related challenges. However, there are alternative operating strategies and technologies that could be implemented to reduce the overall cost of building and operating commuter rail service.

At this point in time, this study has a limited ability to produce direct comparisons between LRT and BRT in cost-effectiveness. The sketch planning model is not capable of distinguishing between LRT and BRT technologies, preventing estimates of the differences in ridership between corridors. However, using the single estimated ridership figures, it is possible to identify specific corridors that would likely perform well with Dedicated BRT service. Corridors with lower ridership figures would be prime candidates for BRT service, given this technology's capability to provide a comparable level of service at a much lower cost. In analyzing the ridership results from this study, it is likely that a number of corridors contained in the Recommended High Capacity Transit Network would operate effectively with the implementation of BRT service rather than LRT. Table 5-2 summarizes the cost effectiveness of both transit technologies in the MAG region and illustrates that BRT would likely prove to be a cost-effective transit alternative in many corridors.

Table 5-2**LRT-BRT Cost Effectiveness Comparison**

Corridor	LRT Annualized Cost (\$ millions)	BRT Annualized Cost (\$ millions)	LRT Cost Effectiveness	BRT Cost Effectiveness
59 th Avenue	\$69.51	\$40.02	\$14.85	\$8.55
Bell Road	\$110.73	\$65.68	\$15.36	\$9.11
Camelback Road	\$35.58	\$20.88	\$12.00	\$7.04
Chandler Boulevard	\$64.44	\$34.22	\$14.44	\$7.67
Main Street	\$38.85	\$28.51	\$10.98	\$6.23
Power Road	\$45.47	\$38.85	\$14.40	\$10.98
Scottsdale Road	\$101.82	\$27.21	\$13.49	\$8.61
SR-51	\$80.20	\$58.23	\$17.82	\$7.72
Union Pacific Chandler Branch	\$47.31	\$34.71	\$10.34	\$7.71

MAG Modeling Results

Overall, the MAG model forecasts around a third more riders than the sketch planning methodology. However, two corridors - Bell Road and the BNSF commuter rail line - can explain over 80 percent of this discrepancy. There are technical reasons for the high MAG model ridership along these corridors, particularly the large forecast growth in the northwest valley. These reasons are fully discussed in an addendum to the Milestone 5 Report. If these two corridors are removed, overall ridership is only 7 percent above the sketch planning results. Table 5-3 compares the sketch planning and four-stage modeling results for subareas in the MAG region.

Table 5-3
Comparison of Modeling Results by Corridor Group

Corridor Group	MAG Model Forecast	Sketch Plan Forecast	Difference
BNSF/Bell Road	85,907	27,823	209%
Central Network	137,185	107,063	28%
UP Yuma/I-10 West	21,034	19,783	6%
East Valley ¹	110,555	109,004	1%
Other	29,634	30,912	-4%
TOTAL (Adjusted)²	210,798	195,722	8%

This grouping shows that while comparisons on a line-by line basis may suggest large differences between the modelling approaches, overall differences are much smaller. The largest difference is due to the congestion problems and population forecasts of the northwest, but that aside the largest impact appears to be the network effects of connectivity, slightly increasing overall ridership.

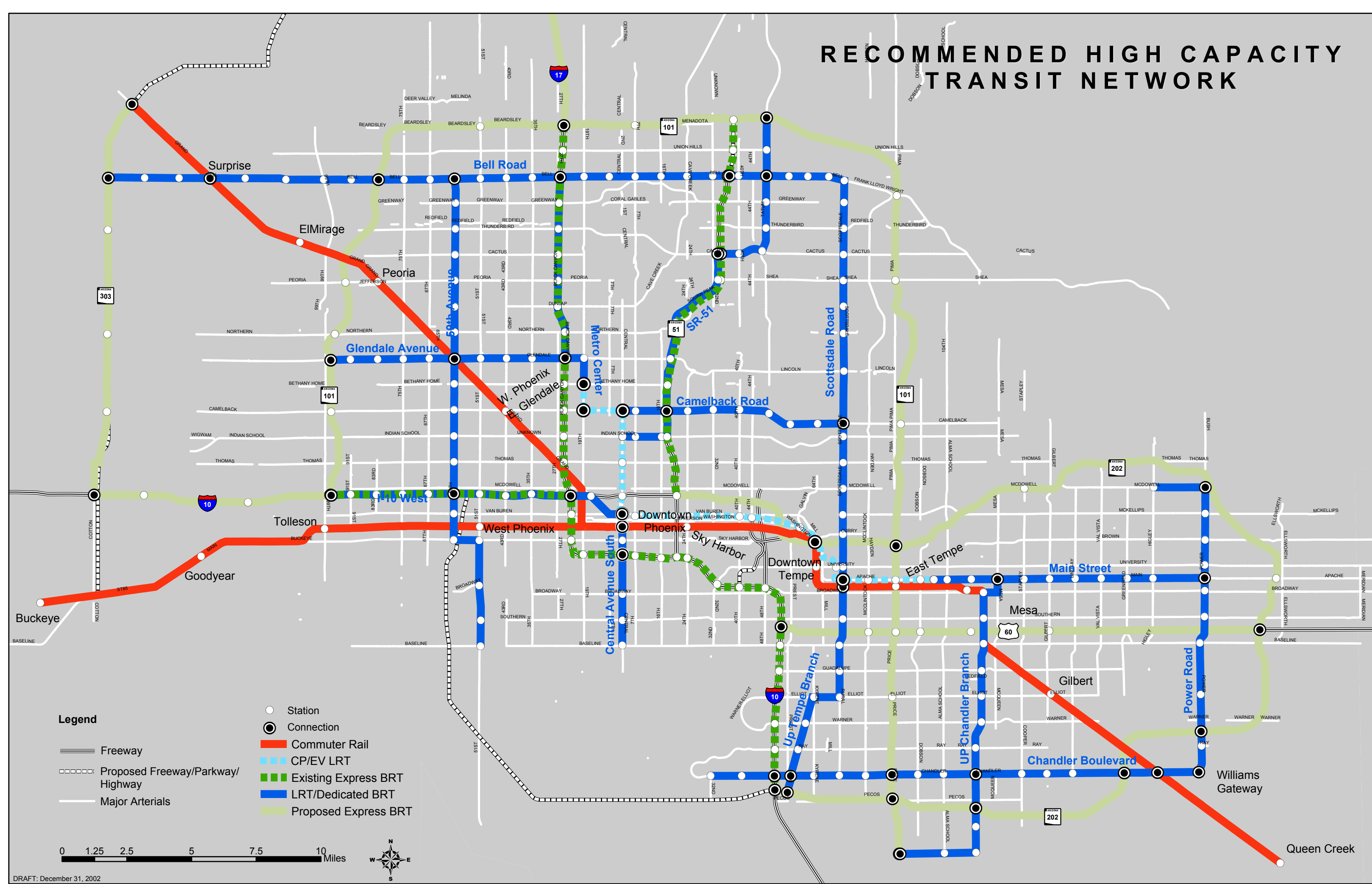
5.2 Recommended High Capacity Transit Network

The overall objective of the Recommended High Capacity Transit Network is the creation of an integrated system of high capacity transit corridors providing efficient and convenient travel throughout the MAG region. An important part of these corridors fulfilling their objective is to ensure that there are connections between the corridors and that these connections facilitate the movement of riders between systems no matter which transit technology is being operated. Exhibit 5-1 illustrates the Recommended High Capacity Transit Network. The likely connection points between each corridor and intersecting corridors are illustrated in this map.

¹Corridors include MetroCenter/I-17, Main Street and CP/EV as one, as well as Power, Chandler, UPSE, UP Chandler Branch

²Does not include BNSF or Bell Road. Forecasts do not add up to total as Metro Center-CP/EV-Main Street corridor is included in both "East Valley" and "Central Network" categories

RECOMMENDED HIGH CAPACITY TRANSIT NETWORK



Legend

Freeway

Proposed Freeway/Parkway/
Highway

Major Arterials

Station

Connection

Commuter Rail

CP/EV LRT

Existing Express BRT

LRT/Dedicated BRT

Proposed Express BRT

0 1.25 2.5 5 7.5 10 Miles



6.0 Implementation Plan

The levels of service described for each of the commuter rail, LRT, and Dedicated BRT corridors in this report represent the *ultimate level of service* that each transit technology must provide to accommodate the ultimate estimated ridership demand in the various corridors. An important component in developing a recommended high capacity transit network is determining when and how the corridors should be implemented. Proper phasing of projects is essential to ensure that growing ridership demands are met and that improvements are scaled to funding levels available. Several criteria are involved in determining the phasing-in of new high capacity transit service. These criteria are essentially similar from technology to technology; however, there are distinctive differences.

Commuter Rail



The Altamont Commuter Express is a recent start-up commuter rail service with 3 daily trains.



Light rail in Denver started as a short 5 mile system. Recent expansions have created a 2-line, 27-mile system.



The Los Angeles Metro Rapid is a limited-stop bus with signal priority. Future phases will include exclusive bus lanes.

This study has explored three major phasing steps for implementing commuter rail service. Each phase represents a dramatic improvement in service above the previous level of service. There are several ways of transitioning between levels of service, including incrementally with as little as a single roundtrip train added each year, or improvements can be implemented through a larger jump from one phase to the next.

Light Rail

Light rail is a very different technology from commuter rail in terms of its operating characteristics. LRT systems are designed to provide frequent, all-day service from the first day of implementation, unlike commuter rail which can be a viable service with only two to three trains operating each day. A primary reason for this initial implementation of frequent service is the large amount of capital investment required to implement LRT. Phasing in of LRT service would primarily consist of gradual shortening of headways and increased spans of service.

Bus Rapid Transit

BRT technology is similar to commuter rail in that the phasing of service is very flexible, and can be implemented of a series of small stages over time to allow for funding availability and ridership growth. The lower infrastructure requirements for BRT allow for minimal levels of investment to begin a basic service and the flexibility of BRT vehicles allows for a staged implementation over many years. Initial operation could consist of “rapid” buses operating with signal priority, progressing up to bus lanes and finally to exclusive corridors paralleling a street, freeway, or rail right-of-way.

6.1 Phasing and Prioritization

Overall phasing of service may result in the total long term capital cost of implementing transit service to be higher than if the service was implemented at full capacity immediately. However, the latter approach is not usually realistic given the cost investment required to implement a full service transit system. Similar to the development of a freeway network when a six lane freeway is widened to eight lanes to meet growing demand, improvements are done to transit systems in phases to match growing ridership demand. This spreads the cost burden over several years or possibly decades allowing for benefits to be provided at an earlier stage than if construction was delayed until the full system could be implemented.

The High Capacity Transit Plan is designed to be the first step in developing and prioritizing the recommended network of high capacity transit services in the MAG region. This prioritization will continue at a more detailed level during the development of the MAG Regional Transportation Plan (RTP). One of the main objectives of the RTP will be to set out a specific prioritization of the transit corridors identified in the recommended network using additional analysis of population and employment projections, an estimation of expected funding availability, and extensive public consultation.

The 16 corridors contained in the Recommended High Capacity Transit Network have been categorized into three groups for the purposes of prioritization. The key considerations in setting forth the prioritization recommendations for the High Capacity Transit network are both quantitative and qualitative. They include:

- Analysis of expected population growth levels and anticipated timing of this future growth.
- Estimated ridership.
- Linkages to the committed network of high capacity transit.
- The cohesiveness of the overall network, ensuring that future corridors link to previously implemented corridors.

The three groups of corridors identified here have been classified as the Short-Term, Middle-Term, and Long-Term Implementation corridors. Assuming a 40 year horizon for the population and employment projections used in this report, the Short-Term corridors would likely be recommended for implementation during the next 15 years, while the Middle-Term corridors would be implemented within a 15-30 year time frame. The Long-Term corridors would complete the high capacity transit network during the final ten years of the study period (2030 to 2040). It is essential to note that these classifications are not permanent. They are designed as a guide for future refinement as part of the RTP process. Changes in

population growth levels, timing, and the location of future growth would result in changes to the corridors contained in each level. The corridors recommended for inclusion in each implementation level are identified in Table 6-1.

Table 6-1

Recommended High Capacity Transit Corridor Phasing

Short-Term Corridors	Medium-Term Corridors	Long-Term Corridors
Bell Road (59 th Avenue to Scottsdale Road)	59 th Avenue (Glendale Avenue to I-10 West)	59 th Avenue (Bell Road to Glendale Avenue and I-10 West to Baseline Road)
BNSF (Start-up Phase – Downtown Phoenix to Bell Road)	BNSF (Start-up to Loop 303, Full Service to Bell Road)	Bell Road (59 th Avenue to Loop 303)
Glendale Avenue	Camelback Road	BNSF (Ultimate to Loop 303)
I-10 West	Central Avenue South	Chandler Boulevard
Main Street	Scottsdale Road/UP Tempe Branch (North of Downtown Scottsdale and South of CP/EV LRT)	Power Road
Metrocenter/I-17	SR-51 (Cactus Avenue to Loop 101)	UP Southeast (Ultimate)
Scottsdale Road/UP Tempe Branch (Downtown Scottsdale to CP/EV LRT)	UP Chandler Branch	
SR-51 (Central Avenue to Cactus Avenue)	UP Southeast (Start-up with reverse commute to Williams Gateway)	
UP Southeast (Start-up)	UP Yuma (Ultimate)	
UP Yuma (Start-up)		

There are recommendations for phased implementation of several of the corridors listed above. The characteristics of these phased implementations are described above. Specifically, the commuter rail corridors will require phased implementation and a period of time in which to build ridership and upgrade the existing rail infrastructure. The Scottsdale Road/UP Tempe Branch corridor is recommended for implementation in two phases as a result of the higher existing congestion and density between downtown Scottsdale and the planned CP/EV alignment. Growth in portions of this corridor to the north and south of these limits occurs further out in the future, allowing for some delay in implementing service. Exhibit 6-1 illustrates these corridors together as the Recommended High Capacity Transit Network.

POTENTIAL IMPLEMENTATION OF CORRIDORS

Legend

- ==== Parkway/Highway
- ==== Proposed Parkway/Highway
- ==== Freeway
- Major Arterials
- Short Term Implementation
- Medium Term Implementation
- Long term Implementation
- Proposed Express BRT
- CP/EV LRT
- Existing Express BRT

0 1.25 2.5 5 7.5 10 Miles

March 17, 2003

6.2 Action Plan

The Recommended High Capacity Transit Network represents the culmination of a process that identified 29 potential high capacity transit corridors throughout the MAG region, refined these corridors, and evaluated them against each other to determine which corridors were best suited to serve growing demand for transportation capacity in the MAG region.

The next step in implementing the recommended network is the inclusion of these corridors in the development of the RTP. This study was the first step in the process of implementation. The next step is the RTP process which will involve a second review of the network corridors, a review of expect funding availability for transit improvements, and consultations with local agencies and the general public to further refine the number and coverage of the recommended corridors.

There are several specific next steps that need to be taken by MAG or local agencies in the MAG region either individually or in concert to ensure that proper preparations are made for providing future high capacity transit service in several of the corridors identified in the Recommended High Capacity Transit Network. Ideally these actions would begin immediately; however, given the need for approval of the RTP and its funding plan, some components may need to wait until the RTP is finalized. The tasks below are designed to be realistic objectives capable of being accomplished during the next three to five years. If these tasks are not completed in this timeframe, delays may be caused to later implementation steps and could delay components of the recommended network. The immediate actions are:

Refined Prioritization of Corridors in the RTP – The RTP process may introduce changes to the prioritization categories presented above. These changes must be determined early on so that local agencies understand the timing for funding availability and future implementation.

Relocation of the BNSF Freight Facilities – BNSF has been considering the relocation and consolidation of several freight rail facilities in downtown Phoenix to sites north of the BNSF mainline north of the existing intermodal facility in El Mirage. The relocation of the BNSF facility is not a simple process and will require extensive consultations between BNSF, local cities in the corridor, MAG, the Federal Railroad Administration (FRA), and the general public. This will likely be a long process for gaining approval of all parties involved and the identification of funding. This time frame makes it imperative that discussions begin soon to determine the feasibility of this strategy.

Begin Negotiations with Union Pacific – Negotiating access rights to freight railroad corridors can be a long drawn-out process that lasts for as many as five to 10 years depending upon the railroad, the local agency, and

the operating characteristics of the corridor. It will be important to have a full understanding of what types of access rights UP will allow in both the UP Yuma and UP Southeast corridors in order to determine what capital costs will be involved in possible track upgrades and additions.

Develop a Specific Commuter Rail Network Plan – Previous studies have already considered commuter rail, largely on a corridor basis, but not in the context of the High Capacity Transit network. The analysis of Commuter Rail suggests very attractive ridership performance for the Startup Phase of commuter rail. However, a separate action-oriented plan is needed to assess the full viability of the startup service, take forward the initial discussions with UP and BNSF during the course of the High Capacity Transit Study, and run the network assumptions through an analysis based on the FTA New Starts criteria.

Perform Detailed Major Investment Studies on Early Implementation Corridors – Each corridor contained within the Recommended High Capacity Transit Network will require some form of Major Investment Study (MIS) to determine precise alignments, operating characteristics, preferred technology, and the overall design of the system. An MIS report includes a detailed refinement of costs, headways, and alignments, while including opportunities for community and policy input into the development of transit service. The outcome of an MIS is usually a more defined picture of what the high capacity transit service will look like in appear and operation. Several of these MIS efforts are underway or in early planning stages and include the Scottsdale-Tempe North-South Transit MIS and the City of Chandler Transit MIS. This recommendation is not intended to be duplicative of these efforts.

It also should be noted that the Central Phoenix/East Valley MIS studied high capacity transit in the City of Mesa east of the current terminus of the Central Phoenix/East Valley LRT. This MIS recommended the implementation of light rail, and as such, the recommendations of this report would not supersede this document. The work being done in these studies was incorporated into the development of corridors for evaluation in this report.

Future MIS reports will build upon the corridors identified in the Recommended High Capacity Transit Network. One of the first steps in this process will occur in the BNSF/Grand Avenue corridor where a recently announced MIS will evaluate both commuter rail and bus rapid transit alternatives.